An Introduction To The Sound System Of Navajo

Part One: Articulatory Phonetics

Ken Hale and Lorraine Honie

MIT

The following sections are designed to familiarize speakers of Navajo with certain basic concepts in articulatory phonetics. Illustrations are primarily from Navajo, but an effort is made to render the material more generally useful by introducing articulatory distinctions made in other languages as well. The material is based on work done by K. Hale and L. Honie at M.I.T. It was supported in part by grants from the National Institute of Health (Grant No. 5 T01 HD 00111-07) and the National Institute of Mental Health (Grant No. 5-T01-MH 13390-05).
I. The Positions of Articulation

1. Compare the sounds /b,d,j,g/, as in:

<table>
<thead>
<tr>
<th>/b/</th>
<th>/d/</th>
<th>/j/</th>
<th>/g/</th>
</tr>
</thead>
<tbody>
<tr>
<td>béésh</td>
<td>dééh</td>
<td>jish</td>
<td>gah</td>
</tr>
<tr>
<td>bis</td>
<td>díí</td>
<td>jádí</td>
<td>gish</td>
</tr>
<tr>
<td>bááh</td>
<td>doo</td>
<td>joo</td>
<td>ge'</td>
</tr>
<tr>
<td></td>
<td>daan</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For each of these sounds describe carefully the actions performed by the lips or tongue during its pronunciation.

/b/: the two lips are placed against one another.

Sounds produced with the lips are termed labial (based on the Latin word for "lip", labium). If both lips are involved, the sound is called bilabial. Navajo /b/ is a bilabial sound, since it is pronounced with the two lips touching each other, as represented in the "x-ray" profile below:
/d/: the tip of the tongue is placed against the gum-ridge directly behind the upper front teeth.

Sounds produced with the tip of the tongue are called apical sounds (from the Latin word for "tip", apex). And sounds produced in the region of the gum-ridge behind the upper front teeth are called alveolar sounds (from the Latin word alveolus, "little hollow", referring to the sockets in which the teeth are set).

The term referring to the tip of the tongue (apical) and the term referring to the gum-ridge (alveolar) can be put together into a single hyphenated term apico-alveolar. This hyphenated term is used to describe the position of articulation
for sounds like Navajo /d/ -- the first part of the term refers to the part of the tongue which is involved (i.e., the tip or apex), and the second part refers to the point at which contact is made (i.e., the gum directly behind the teeth, sometimes called the alveolar ridge).

The apico-alveolar position of articulation can be represented in an x-ray profile as follows:

/apico-alveolar articulation/

/j/: the blade of the tongue is placed against the gum-ridge behind the upper front teeth.

The blade of the tongue is the flat upper surface of the tongue directly behind the tip. Sounds produced with this portion
of the tongue are referred to by means of the term laminal (from Latin lamina "thin plate, blade"). And as we saw earlier, sounds produced against the gum-ridge are termed alveolar. The two terms can be combined to create the term lamino-alveolar which is used to describe the position of articulation for sounds like Navajo /j/ -- i.e., the blade of the tongue (lamina) is placed against the gum-ridge (the alveolar ridge) behind the upper front teeth.

Lamino-alveolar articulation can be pictured as follows:

![Lamino-alveolar articulation](image)

/g/: the back of the tongue is placed against the roof of the mouth at the point where the soft and hard palates meet.
Sounds produced with the back of the tongue are referred to by the term *dorsal* (from Latin *dorsum* "back"), and sounds which are produced against the soft palate are termed *velar* (from Latin *velum* "veil", because the soft palate is thought by some people to be somewhat like a veil). The two terms are combined to give the hyphenated term *dorso-velar* which is used to describe the position of articulation for sounds like Navajo /g/ -- i.e., the back (*dorsum*) of the tongue is placed against the soft palate (*velum*).

The *dorso-velar* position of articulation can be depicted as follows:

![Dorso-velar Articulation](image)

2. The four sounds /b, d, j, g/ exemplify the major positions
of articulation of Navajo:

<table>
<thead>
<tr>
<th>bilabial</th>
<th>apico-alveolar</th>
<th>lamino-alveolar</th>
<th>dorso-velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>d</td>
<td>j</td>
<td>g</td>
</tr>
</tbody>
</table>

But, in fact, all of the Navajo sounds known as consonants (a term we will define later) can be described partially in terms of these positions of articulation. That is, each consonant sound belongs to a particular position class. In order to test your understanding of this, consider the following sounds and identify the position of articulation to which each belongs:

/t/ as in: táá', tin, tó, ...

/ch/ as in: chaa', chin, ...

/k/ as in: kin, kó', ké, ...

If you compare these sounds with those already studied above, it should be easy to see that /t/ is in the same position of articulation as /d/; /ch/ is in the same position as /j/; and /k/ is in the same position as /g/. Thus, we might arrange them in a chart as follows:

<table>
<thead>
<tr>
<th>bilabial</th>
<th>apico-alveolar</th>
<th>lamino-alveolar</th>
<th>dorso-velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>d</td>
<td>j</td>
<td>g</td>
</tr>
<tr>
<td>t</td>
<td>ch</td>
<td>k</td>
<td></td>
</tr>
</tbody>
</table>
Now consider the sounds

/m/ as in: mósi, mə'ii, máazo, ...
/n/ as in: naaki, ni', noo', ...

To what positions do they belong? Again, by comparing them to the sounds we already have, it is relatively easy to identify their positions -- /m/ is produced in the same position as /b/, and /n/ is produced in the same position as /d/ and /t/:

<table>
<thead>
<tr>
<th>bilabial</th>
<th>apico-alveolar</th>
<th>lamino-alveolar</th>
<th>dorso-velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>d</td>
<td>j</td>
<td>g</td>
</tr>
<tr>
<td>t</td>
<td>ch</td>
<td>k</td>
<td></td>
</tr>
<tr>
<td>m</td>
<td>n</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A somewhat more difficult task is that of identifying the position of articulation of the following sounds:

/s/ as in: sin, saad, sq', ...
/sh/ as in: shí, shá, shoo', ...
/x, h/ as in: hah, hééi, ...

The reason this is more difficult is because the tongue does not actually make contact at the position of articulation. Instead, the tongue is held in such a way as to allow the breath to force its way through at the point of articulation.
In the case of /s/, the breath forces its way between the tip of the tongue and the alveolar ridge -- therefore, it is an apico-alveolar sound. You can convince yourself of this by producing an /s/ and then stopping the flow of air at the point where the hissing sound is produced by forcing the tongue upward. When you do this, notice that the /s/ turns into a sound which is like /t/ or /d/. This shows that /s/ is in the same position as /t/ and /d/, i.e., apico-alveolar position.

Now consider /sh/ -- in this case, the breath forces its way between the blade of the tongue and the alveolar ridge. Therefore, /sh/ is a lamino-alveolar sound. If you produce a /sh/ and then stop the air-flow by forcing the tongue upward, the /sh/ turns into a sound which is like /ch/ or /j/.

The sound written /x/ or /h/ is produced by forcing the breath between the back of the tongue and the soft palate -- it is therefore a dorso-velar sound. If you produce the sound /x, h/ and then stop the air-flow by forcing the tongue upward, the /x, h/ turns into a sound which is like /k/ or /g/.

We can put these three sounds into the phonetic chart as follows:

<table>
<thead>
<tr>
<th>bilabial</th>
<th>apico-alveolar</th>
<th>lamino-alveolar</th>
<th>dorso-velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>d</td>
<td>j</td>
<td>g</td>
</tr>
<tr>
<td>t</td>
<td></td>
<td>ch</td>
<td>k</td>
</tr>
<tr>
<td>m</td>
<td>n</td>
<td>sh</td>
<td></td>
</tr>
<tr>
<td>s</td>
<td></td>
<td></td>
<td>x, h</td>
</tr>
</tbody>
</table>
3. Navajo has four major positions of articulation. If we compare Navajo to English, we see that English also uses these four positions. Consider the following English sounds, and attempt to identify their positions:

/p/ as in: pill, pale.
/t/ as in: till, tale.
/ch/ as in: chill, chain.
/k/ as in: kill, cane.
/b/ as in: bill, bale.
/d/ as in: dill, dale.
/j/ as in: jill, jail.
/g/ as in: gill, gale.
/s/ as in: sill, sale.
/sh/ as in: shill, shale.
/m/ as in: mill, male.
/n/ as in: nil, nail.

These English sounds can be arranged in our phonetic chart in the following manner:

<table>
<thead>
<tr>
<th>bilabial</th>
<th>apico-alveolar</th>
<th>lamino-alveolar</th>
<th>dorso-velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>p</td>
<td>t</td>
<td>ch</td>
<td>k</td>
</tr>
<tr>
<td>b</td>
<td>d</td>
<td>j</td>
<td>g</td>
</tr>
<tr>
<td>m</td>
<td>n</td>
<td>s</td>
<td>sh</td>
</tr>
</tbody>
</table>
However, English has some sounds which are not produced in any of the four positions of articulation which we have identified so far.

Consider, for example, the sound /f/, as in: fill, fail, full, fat. In pronouncing /f/, the lower lip articulates against the tips of the upper front teeth. It is not a bilabial sound, like Navajo /b/ (or English /p/ and /b/), since the two lips do not articulate against one another. English /f/ is a labial sound, since the lip is involved, but the teeth are also involved. Sounds which are produced against the teeth are termed dental (from Latin dentalis, based on dens, dentis "tooth"). Using our familiar convention for creating hyphenated terms for positions of articulation, we have labio-dental which describes the articulation of sounds like English /f/ -- i.e., the lip (labium) against the teeth (dent-).

The labio-dental position of articulation can be pictured as follows:

[Diagram of labio-dental articulation]
Now consider the English sound /th/, as in: thin, thing, thigh, thought. This sound is produced by placing the blade of the tongue against the tips of the upper front teeth. It is therefore a lamino-dental sound -- i.e., the blade (lamina) against the teeth (dent-). This position of articulation can be pictured as follows:

![Lamino-dental Articulation Diagram]

**lamino-dental articulation**

4. Exercises.

(1) Identify the following Navajo sounds in terms of their positions of articulation:

/z/ as in: zas.

/zh/ as in: názhah.
/gh/ as in: ġhaaj1'.
/t'/ as in: t'iis.
/ch'/ as in: ch'ah.
/k'/ as in: k'ad.
/dz/ as in: dzéeh.
/ts/ as in: tsín.
/ts'/ as in: ts'ín.

(2) The portion of the hard palate which is indicated by the arrows in the following drawing can be referred to by the term dome.

And sounds produced against the dome can be referred to as domal sounds. In many of the
languages of India and Australia, there exists a class of consonants which can be called apico-
domal\textsuperscript{1}. Such sounds are written in phonetic transcription as $[t, d, s, z]$. The apico-domal sound $[s]$ is also found much closer to home -- namely, in the Pima-Papago language of southern Arizona and Northern Sonora; and the sound $[z]$ is found in Hopi (where it is normally written with the symbol $\mathfrak{r}$).

Using your knowledge of how the hyphenated phonetic terms are made up, try to imagine what an apico-domal sound is like, and draw an x-ray profile of the apico-domal position of articulation.

(3) The portion of the tongue which is directly opposed to the dome (and indicated by the arrows in the picture below) can be referred to as the center of the tongue.

\textsuperscript{1} These sounds are often called cerebrals by students of the languages of India.
Sounds produced with the center of the tongue can be termed central. In a number of languages of the world -- e.g., Xhosa of southern Africa, Hungarian of Europe, and Jemez of the American Southwest, there exist sounds appropriately described as centro-domal. The centro-domal sound which occurs in Jemez might be written in phonetic notation as [t̪v] (there is no established phonetic symbol for this sound, so we are permitted to make one up).

Using your knowledge of the way in which the hyphenated terms are constructed, try to imagine what a centro-domal sound is like, and draw an x-ray profile of the centro-domal position of articulation.
5. Answers:

(1) /z/ apico-alveolar
    /zh/ lamino-alveolar
    /gh/ dorso-velar
    /t'/ apico-alveolar
    /ch'/ lamino-alveolar
    /k'/ dorso-velar
    /dz, ts, ts'/ apico-alveolar.

(2) apico-domal articulation
centro-domal articulation
II. The Manners of Articulation: Nasal vs. Stop.

1. The Navajo sounds /b, d, j, g/ are different from one another because of the fact that they are produced at different positions of articulation. But this is not the only way in which sounds can differ. To realize this, it is enough to compare the sounds /b/ and /m/. These two sounds are produced at the same position of articulation — i.e., bilabial position. Nonetheless, they are different. The way in which the two sounds differ becomes very clear when one considers how they are produced.

Consider first how the sound /m/ is produced. Notice that it is possible to "hang on" to an m-sound — that is, it is possible to begin an m-sound and to continue producing it for as long a period as one is able to keep breathing outward: m m m m m m ... This is, in fact, what a person does when he hums a tune. Because of this, it is rather easy to study what is happening when an /m/ is produced.

Since the lips are closed during the pronunciation of /m/, it is obvious that the breath cannot escape through the mouth. Nonetheless, the breath does escape, otherwise it would be impossible to "hang on" to an m-sound as one does in humming. What happens
during the production of /m/ is that the breath -- i.e., the air proceeding outward from the lungs -- is allowed to escape through the nose. It is easy to convince yourself that this is happening by producing a prolonged m-sound and then suddenly pinching the nose shut at the nostrils; this makes it impossible to continue the m-sound for more than a fraction of a second, because the outward flow of breath is totally cut off at the nostrils. Another way to appreciate the fact that the breath passes out through the nasal cavity during the production of /m/ is the following: produce a prolonged m-sound and place a finger directly beneath the nose; when one does this, one can feel the warmth of the outward flowing breath.

Now contrast all of this with what happens when the sound /b/ is produced. Notice first that it is not possible to continue breathing outward while "hanging on" to a b-sound. The reason for this is that the breath cannot escape -- it cannot escape through the mouth, because the lips are closed, and it also cannot escape through the nose. If the breath did escape through the nose, it would be an m-sound and not a b-sound. And this is the basic difference between /m/ and /b/:

/m/  the breath escapes through the nose.
/b/  the breath does not escape through the nose.
Since /m/ is produced by allowing the breath to pass through the nose, it is referred to as a nasal sound (from Latin nasus "nose").

By contrast, /b/ is referred to as a stop sound. The reason for this is quite clear. When /b/ is produced, the outward flow of breath is completely cut off, or stopped, for a short period. That is to say, when the speech organs are in the proper position for producing /b/, the breath is not allowed to escape either through the mouth or through the nose -- it is only when the lips are opened as the speaker goes on to produce the next sound that the breath is allowed to resume its outward movement.

The two sounds /b/ and /m/ have something in common, namely, their position of articulation -- they are both bilabials. But there is also something which serves to distinguish the two sounds. This is their manner of articulation -- /b/ is a stop, while /m/ is a nasal. Now compare the two sounds /d/ and /n/. They also have in common their position of articulation -- both are apico-alveolar. And they differ in exactly the same way as do /b/ and /m/. Thus, /d/ is a stop while /n/ is a nasal.

It is common practice in phonetic descriptions to arrange the sounds of a language in a phonetic chart in such a way as to represent both their position and their manner of articulation. Customarily, in phonetic charts, the sounds are arranged in columns according to position of articulation and in rows according to manner.
Thus, the four sounds /b, d, m, n/ would be charted as follows:

<table>
<thead>
<tr>
<th></th>
<th>bilabial</th>
<th>apico-alveolar</th>
</tr>
</thead>
<tbody>
<tr>
<td>stops</td>
<td>b</td>
<td>d</td>
</tr>
<tr>
<td>nasals</td>
<td>m</td>
<td>n</td>
</tr>
</tbody>
</table>

What about the sounds /j/ and /g/ -- are they stops or nasals? The answer to this question should not be difficult to determine. If one tries to "hang on" to a /j/ or a /g/ while breathing outward, one notices that the breath is unable to escape. Therefore, these sounds must be stops. They fit into our phonetic chart as follows:

<table>
<thead>
<tr>
<th></th>
<th>bilabial</th>
<th>apico-alveolar</th>
<th>lamino-alveolar</th>
<th>dorso-velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>stops</td>
<td>b</td>
<td>d</td>
<td>j</td>
<td>g</td>
</tr>
<tr>
<td>nasals</td>
<td>m</td>
<td>n</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Observe that there are stops at all four positions of articulation in Navajo, but there are nasals at only two positions. There is a bilabial nasal /m/ corresponding to the bilabial stop /b/, and there is an apico-alveolar nasal /n/ corresponding to the apico-alveolar stop /d/. But there is, in Navajo, no lamino-alveolar nasal corresponding to the stop /j/, and there is no dorso-velar nasal corresponding to the stop /g/. The question one
might ask at this point is whether there is any such thing as a lamino-alveolar nasal or a dorso-velar nasal. You should be able to answer this question, in principle, by simply trying it out: place the tongue in lamino-alveolar or dorso-velar position and allow the breath to pass out through the nose. If you do this in lamino-alveolar position, the sound you produce is the one written /n/ in such Spanish words as cañon, señor, mañana. This is the lamino-alveolar nasal. And if you place the tongue in dorso-velar position and allow the breath to pass out through the nose, you produce the sound written /ŋ/ in such English words as: sing, song, hang. This is the dorso-velar nasal, and it is commonly represented in phonetic notation by means of the symbol [ŋ], sometimes called the "eng" or "engma". This sound is very common in Hopi.

We can fill out our phonetic chart as follows:

<table>
<thead>
<tr>
<th></th>
<th>bilabial</th>
<th>apico-alveolar</th>
<th>lamino-alveolar</th>
<th>dorso-velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>stops</td>
<td>b</td>
<td>d</td>
<td>j</td>
<td>g</td>
</tr>
<tr>
<td>nasals</td>
<td>m</td>
<td>n</td>
<td>(ŋ)</td>
<td>(ŋ)</td>
</tr>
</tbody>
</table>

The lamino-alveolar and dorso-velar nasals are enclosed in parentheses because they are not a part of the Navajo sound system, although they exist in other languages.
2. How is a nasal produced? What happens in the mouth and nose when a nasal is produced?

To answer these questions, it is useful first to consider what happens during breathing. There are two passages through which the breath may pass as it moves outward from the lungs. These are the nasal passage and the oral (mouth) passage, as shown in the following x-ray profile:

When one breathes through the nose, the air exits through the nasal passage; and when one breathes through the mouth, the breath
exits through the oral passage. The route which the breath takes can be controlled by means of the velic valve. This valve is formed by the soft palate (i.e., the velum) and the rear wall of the throat (or pharynx). The velum is capable of moving back against the rear wall of the throat so as to block the way into the nasal passage. When the velic valve is open, as in the x-ray profile above, the breath is allowed to enter into the nasal passage and to flow out through the nose. But when the velic valve is closed, as in the x-ray profile below, the breath is not allowed into the nasal passage:

It is possible to feel the opening and closing of the velic valve by pronouncing the Navajo syllables /'aa/ and /'aa/ repeatedly in succession:
'aa'aa'aa'aa'aa'aa ...  

The movement of the velic valve is especially perceptible when one attempts to pronounce these successive syllables without the intervening glottal stop /'/:  

aaaaaaaaaaaaaaa ...  

The syllable /aa/ is pronounced with velic valve open, while the syllable /aa/ is pronounced with the velic valve closed.  

Now the difference, from an articulatory point of view, between a stop sound and a nasal sound depends on whether the velic valve is open or not. Thus, for example, the bilabial stop /b/ is produced with the lips together and the velic valve closed.  

bilabial stop articulation
And the bilabial nasal /m/ is produced with the lips together and the velic valve open:

bilabial nasal articulation

3. Exercises.

(1) Draw x-ray profiles of apico-alveolar nasal and apico-alveolar stop articulation.
(2) Many languages of India and Australia have a sound which can be described as an apico-domal nasal, written \([\eta]\) in phonetic notation. Draw an x-ray profile of apico-domal nasal articulation.

(3) In many languages of the world, there are stops and nasals which are produced by placing the blade of the tongue against the upper front teeth. These sounds are represented \([t, d, \eta]\) in phonetic notation. What would be the hyphenated term which could be used to describe the position of articulation of these sounds?

(4) Draw an x-ray profile representing the position and manner of articulation of 1) Navajo /\textipa{k}/, of \(\text{k'\dza},\) \(\text{kánaashá},\) etc., and 1l) the English /\textipa{ng}/ (\(=[\eta]\)) of \text{sing}, \text{long}.
4. Answers.

(1) apico-alveolar-nasal articulation

apico-alveolar stop articulation
(2) apico-domal nasal articulation

(3) The sounds [t, d, n] are lamino-dentals.

(4) Navajo /k/
English /ng/ (=ŋ)
III. The Manners of Articulation: Stop vs. Fricative.

1. In the preceding discussion, we have identified one of the important contrasts in manner of articulation -- namely, the distinction between stops and nasals. But this is only one of many manner distinctions which function in the phonology (i.e., sound system) of Navajo.

Consider, for example, the distinction between Navajo /d/ and /z/ -- as in the pair

/daz/ 'weight'
/zaz/ 'snow'

These two sounds share the same position of articulation -- i.e., they are apico-alveolars. And neither of them is a nasal, since the velic valve is left closed during their production. But /d/ and /z/ are distinct sounds in Navajo. The way in which they differ can be appreciated immediately if one attempts to "hang on" to them in the sense described in the previous section. Navajo /d/ is a stop, since during its production the breath is momentarily prevented from escaping either through the mouth or through the nose. But Navajo /z/ is not a stop; it is possible to "hang on" to a /z/ as one breathes outward, thereby producing a continuous buzz: zzzzz ... Recall that nasals also have the
property that one can "hang on" to them in this way. However, /z/ is not a nasal, since the breath does not exit through the nasal passage during its production.

When /z/ is pronounced, the breath is allowed to escape over the tip of the tongue. The tongue tip is held close to the alveolar ridge, but it does not actually make contact with it. Since a narrow opening is left between the tongue tip and the alveolar ridge, the breath is not stopped, as it is in the case of /d/.

Sounds like Navajo /z/ can be referred to as continuants, because they can be "continued", so to speak, as one breathes outward -- this is the same as saying that one can "hang on" to them. But there is another term which is also used for the class of continuants to which Navajo /z/ belongs -- namely, fricative. Sounds like /z/ are called fricatives because of the fact that they are produced by creating a narrow passage through which the outgoing breath must force itself. Since the breath must squeeze through a narrow passage, a sort of friction is created as it passes through -- that is, the breath is set into turbulence at the point of articulation. This is what gives fricatives their distinctive sound.

The sounds /d/ and /z/ are produced at the same position of articulation. To appreciate this, one can, as mentioned earlier, produce a /z/ and then shut off the narrow passage through which
the breath escapes -- if one does this, one notices that the /z/ turns into its stop counterpart /d/. Navajo /z/ is, therefore, an apico-alveolar fricative.

The distinction between stop and fricative manners of articulation has been illustrated above by means of the pair /d, z/. The same distinction can be illustrated by means of the pairs /j, zh/ and /g, gh/. The sounds /j/ and /zh/ are both lamino-alveolar, but the former is a stop, while the latter is a fricative. And sounds /g/ and /gh/ share dorso-velar position of articulation, but /g/ is a stop, while /gh/ is a fricative.

We are now in a position to add some more detail to our growing phonetic chart by labeling the fricative series:

<table>
<thead>
<tr>
<th></th>
<th>bilabial</th>
<th>apico-alveolar</th>
<th>lamino-alveolar</th>
<th>dorso-velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>stops</td>
<td>b</td>
<td>d</td>
<td>j</td>
<td>g</td>
</tr>
<tr>
<td>fricatives</td>
<td>-</td>
<td>z</td>
<td>zh</td>
<td>gh</td>
</tr>
<tr>
<td>nasals</td>
<td>m</td>
<td>n</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

2. As we begin to fill out the phonetic chart with sounds which exist in Navajo, we discover that there are certain "gaps". These are indicated by means of dashes in the version of the chart just given. In the previous section, it was pointed out
that lamino-alveolar and dorso-velar nasals (n and ñ) do exist in some languages, but they are lacking in Navajo, hence the gaps in the nasal row in the chart. Notice also that there is a gap in the chart for the sound which would be described by the term **bilabial fricative**. Such a sound does not exist in Navajo, but it should not be difficult to imagine what the sound would be like. It would be produced by placing the lips close together in such a way as to set the outward flowing breath into local turbulence as it passed between them. One sound produced in this way is found in Spanish, where it is written b or v -- it appears in such words as: lobo "wolf", uya "grape". An accepted phonetic symbol for it is [β]. What about the English sound written v? Is it a stop or a fricative? Clearly, it must be a fricative, since during its production the breath is allowed to escape by passing between the lower lip and the tips of the upper front teeth -- it is, therefore, a **labio-dental fricative**. The English /v/ is different from the Spanish sound, though, since the Spanish sound is **bilabial** rather than **labio-dental**.

3. Exercises.

(1) Some of the sounds of Navajo have not yet been discussed in this section. Nonetheless, they participate in the distinction stop vs. fricative.
Which of the following sounds are stops, and which are fricatives?

/s/
/k/
/t/
/sh/
/x,h/
/ch/

(2) The technical terms we have been developing are used to describe the position and manner of articulation of individual sounds. For example, Navajo /g/ can be described as a dorso-velar stop. Using the terminology so-far developed, describe the following Navajo sounds:

/zh/
/ch/
/j/
/t/
/s/
/sh/
/x,h/
/b/
/n/
/d/
/z/
(3) The technical terms of phonetics are a kind of "short-hand" for longer, more detailed descriptions of the way in which individual sounds are produced. Thus, the term **bilabial stop**, is short for something like the following:

"The lips are placed against one another and the velic valve is kept closed so that the outward moving breath is momentarily prevented from escaping either through the oral passage or through the nasal passage."

Below are given a number of the longer descriptions of the position and manner of articulation of individual sounds. For each description, provide the shorter technical term which corresponds to it --- also, in each case identify one or more sounds which fit the description.

(i) "The tip of the tongue is placed against the alveolar ridge and the velic valve is kept open so that the outward moving breath is allowed to exit through the nasal passage."

(ii) "The blade of the tongue is held close to the alveolar ridge in such a way as to create a restricted passage through which the breath
is allowed to pass; the velic valve is closed."

(iii) "The blade of the tongue is placed against the upper front teeth and the velic valve is kept open so that the breath is allowed to exit through the nasal passage."

(iv) "The back of the tongue is held close to the soft palate in such a way as to create a restricted passage through which the breath is allowed to pass; the velic valve is closed."

(v) "The tip of the tongue is curved upwards and backwards; it nearly touches the dome of the mouth, thereby creating a restricted passage through which the breath can pass; the velic valve is closed."

(vi) "The tip of the tongue is placed against the alveolar ridge and the velic valve is kept closed so that the breath is momentarily prevented from escaping either through the mouth or through the nose."
(4) Arrange the following English sounds in a phonetic chart:

/m/ as in: mill
/p/ as in: pill
/n/ as in: nil
/t/ as in: till
/s/ as in: sill
/ch/ as in: chill
/sh/ as in: shale
/th/ as in: thin
/k/ as in: kill
/ng/ as in: long
/f/ as in: fill
4. Answers.

(1) stops: /t, ch, k/
    fricatives: /s, sh, x, h/

(2) /zh/ lamino-alveolar fricative
    /ch/ lamino-alveolar stop
    /j/ lamino-alveolar stop
    /t/ apico-alveolar stop
    /s/ apico-alveolar fricative
    /sh/ lamino-alveolar fricative
    /x,h/ dorso-velar fricative
    /b/ bilabial stop
    /n/ apico-alveolar stop
    /d/ apico-alveolar stop
    /z/ apico-alveolar fricative

(3) (i) apico-alveolar nasal: n.
    (ii) lamino-alveolar fricative: sh, zh.
    (iii) lamino-dental nasal: ŋ.
    (iv) dorso-velar fricative: x, gh.
    (v) apico-domal fricative: ş, ž.
    (vi) apico-alveolar stop: t, d.
(4)

<table>
<thead>
<tr>
<th></th>
<th>bilabial</th>
<th>labio-</th>
<th>lamino-</th>
<th>apico-</th>
<th>lamino-</th>
<th>dorso-</th>
</tr>
</thead>
<tbody>
<tr>
<td>stop</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>p</td>
<td></td>
<td></td>
<td>t</td>
<td>ch</td>
<td>k</td>
</tr>
<tr>
<td>fricative</td>
<td></td>
<td>f</td>
<td></td>
<td>s</td>
<td>sh</td>
<td></td>
</tr>
<tr>
<td>nasal</td>
<td></td>
<td>m</td>
<td></td>
<td>n</td>
<td></td>
<td>ng</td>
</tr>
</tbody>
</table>

1. We have made a fundamental distinction between position and manner of articulation. The positions of articulation have been defined in terms of the movable organs of speech, or, as they are sometimes called, the articulators (e.g., the lips and tongue), which are capable of approaching or contacting a variety of points along the upper surface of the mouth. The manners of articulation, on the other hand, are defined in terms of what happens to the breath as it passes outward from the lungs -- in the case of nasals, the breath is directed through the nasal passage; in the case of stops its outward flow is momentarily completely interrupted; and in the case of fricatives, the breath is forced through a narrow restricted passage created at some position of articulation. Consider, for example, the two sounds /s/ and /z/. Notice that they are produced in the same position of articulation -- i.e., apico-alveolar -- and both are fricatives. Nonetheless, they are quite different. One way to describe the difference is to say that /s/ is a hissing sound, while /z/ is a buzzing sound. This becomes clear, for example, if one covers ones ears and produces a prolonged /z/, alternating this with a prolonged /s/: zzzzzzzzzzzz... The /z/ is accompanied by a loud buzzing noise which stops as soon as the /z/ is turned to /s/. The name given to this buzzing sound is voice, and the difference between /z/ and /s/ can be described
in terms of the presence or absence of voice. Since the buzzing is present during the production of /z/, it is said to be voiced; and since the buzzing is absent during the production of /s/, it is said to be voiceless.

The same experiment can be used to distinguish /zh/ from /sh/ and to distinguish /gh/ from /x,h/. By our definition, /zh/ and /gh/ are voiced, since they are accompanied by the buzzing which is characteristic of voice. By contrast, /sh/ and /x,h/ are voiceless, because they are not accompanied by the buzzing noise.

Another way in which one can become aware of the difference between voiced and voiceless sounds is to place ones fingertips against the front of the throat, against the protrusion called "the Adam's apple", while producing a prolonged /z/ and alternating it with a prolonged /s/. Not only can one hear the buzzing noise which accompanies /z/, but one can also feel a slight vibration in the throat while the /z/ is being produced -- the vibration cuts off when one changes from /z/ to /s/. This vibration is produced by the larynx, or "voice box", which is located at the top of the trachea, or "wind pipe", as shown in the following drawing:
The larynx consists, in part, of two sets of opposed muscular structures, called the vocal bands (also vocal cords or vocal folds). The vocal bands are capable of a variety of adjustments. They can be held far apart, which is the way they are held when one breathes normally. If one could look down into the throat and see the larynx, it would look roughly like the following picture if the vocal bands were in the position for ordinary breathing:

```
\[ \text{larynx viewed from above} \]
\[ \text{(vocal bands apart)} \]
```
The vocal bands can also be held tightly together so that no breath can pass upward through the larynx. This is the position which the vocal bands assume when one holds one’s breath. It might be depicted roughly as follows:

\[ \text{larynx viewed from above} \]
\[ (\text{vocal bands closed}) \]

As we have seen, the vocal bands can be held wide open, or they can be held tightly closed. But there are many intermediate adjustments between these extremes. One of these intermediate adjustments is the one which is important in producing voice. In producing voice, the vocal bands are held together, but not so tightly as to prevent the breath from passing. Instead, the vocal bands are held together in such a way as to let the breath force its way between them and to set them into vibration. This is similar to what happens when a person blows between two blades of grass held parallel. The vibration produced in this way is known as voice. When one produces Navajo /z/, the vocal bands are in the lightly closed position so that the outgoing breath sets them into vibration; but when one produces its voiceless counterpart /s/, the vocal bands are held open and are therefore completely inactive as the breath passes through the larynx unhindered.
The distinction between voiced and voiceless fricatives can be represented in our phonetic chart as follows:

<table>
<thead>
<tr>
<th></th>
<th>bilabial</th>
<th>apico-alveolar</th>
<th>lamino-alveolar</th>
<th>dorso-velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>stop</td>
<td>b</td>
<td>d</td>
<td>j</td>
<td>g</td>
</tr>
<tr>
<td>fricatives</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>voiceless</td>
<td>-</td>
<td>s</td>
<td>sh</td>
<td>x, h</td>
</tr>
<tr>
<td>voiced</td>
<td></td>
<td>z</td>
<td>zh</td>
<td>gh</td>
</tr>
<tr>
<td>nasals</td>
<td>m</td>
<td>n</td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

2. We have seen that there are two kinds, or series, of fricatives in Navajo -- one series is voiceless, the other is voiced. How about the stops? Is there only one series, or are there more? In answering this question, let us compare first the two sounds /d/ and /t/, as in the pair of words:

/\textit{bidaa}'/ 'his lip'
/\textit{bitaa}'/ 'his father'

or in
/\textit{dééh}/ 'tea'
/\textit{tééh}/ 'valley, deep water'

Both these sounds are apico-alveolar stops, but they are nevertheless distinct. There must, therefore, be some additional manner of articulation which distinguishes them.
An easy way to appreciate the difference between /t/ and /d/ is to hold one's fingers directly in front of the mouth and to produce, successively, the syllables /ta/ and /da/. When /ta/ is pronounced, there is a noticeable, strong "puff" of breath associated with the t-sound; while in the case of /da/, the puff of breath is very weak, if not altogether absent. Now, the same sort of difference can be seen when one compares /j/ and /ch/ and when one compares /g/ and /k/:

/ta/ vs. /da/
/cha/ vs. /ja/
/ka/ vs. /ga/

All of the sounds /t, ch, k/ are characterized by the strong puff of breath, while the sounds /d, j, g/ do not have this puff of breath, or else they have it only very weakly.

The puff of breath which accompanies /t, ch, k/ is known as aspiration, and sounds which have it are said to be aspirated. Sounds like /d, j, g/ which do not have aspiration, are said to be unaspirated.

Aspiration is probably produced in the following way. Recall that when a stop consonant is pronounced the breath is momentarily prevented from escaping either through the nose or out the mouth. When the stop is released, the breath can then resume its outward flow. What causes the breath to move outward in the first place is pressure on the lungs created by certain muscles in the rib cage.
Now, it is possible to vary the pressure on the lungs and thereby to vary the force with which the breath flows outward. This means also that it is possible to vary the pressure which builds up before the release when a stop consonant is produced. It is reasonable to assume that the difference between aspirated and unaspirated stops in Navajo is achieved by allowing relatively more pressure to build up in producing the aspirated stops than in producing the unaspirated stops.

There is another feature associated with the Navajo aspirated /t/ and /ch/ which should, perhaps, be mentioned at this point. When /t/ is produced, the tongue is in apico-alveolar position, and when /ch/ is produced, the tongue is in lamino-alveolar position. However, at the same time, the back of the tongue is often somewhat raised. Because of this, when these stops are released, and the breath rushes outward, there is a tendency for it to be set into local turbulence in the dorso-velar region. Thus, /t/ and /ch/ sometimes sound as if they were immediately followed by a voiceless dorso-velar fricative: $t^X$, $ch^X$ -- this accompaniment is called velarization. In some words, this velarization is quite prominent; and is even written, as in the word /ni[chxon]/.

The aspirated unaspirated distinction can be incorporated into the phonetic chart as follows:
<table>
<thead>
<tr>
<th></th>
<th>bilabial</th>
<th>apico-alveolar</th>
<th>lamino-alveolar</th>
<th>dorso-velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>stop</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>unaspirated</td>
<td>b</td>
<td>d</td>
<td>j</td>
<td>g</td>
</tr>
<tr>
<td>aspirated</td>
<td>-</td>
<td>t</td>
<td>ch</td>
<td>k</td>
</tr>
<tr>
<td>fricatives</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>voiceless</td>
<td>-</td>
<td>s</td>
<td>sh</td>
<td>x, h</td>
</tr>
<tr>
<td>voiced</td>
<td>-</td>
<td>z</td>
<td>zh</td>
<td>gh</td>
</tr>
<tr>
<td>nasals</td>
<td>m</td>
<td>n</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

3. Consider the following three words:

/bida'/  'his nephew'
/bita'/  'between them'
/bit'a'/  'its wing'

These words are different only because of the medial stop, i.e., the sounds which are underlined below:

/bida'/
/bita'/
/bit'a'/

We have seen that the difference between /d/ and /t/ is in the feature of aspiration -- /d/ is unaspirated, and /t/ is aspirated. Now how does /t'/ fit into this picture? Notice that it is also an apico-alveolar stop, but it is clearly different from /t/ or /d/.

The thing that seems to characterize /t'/, as compared to the other apico-alveolar stops, is that it is released with a sort of "snap" or "pop". This sort of accompaniment is called glottalization,
and the way in which it is produced will be described momentarily. Sounds which are produced with this "snap" are said to be glottalized. The glottalized stop /t'/ is produced at apico-alveolar and dorso-velar positions -- these are /ch'/ and /k'/, respectively.

To understand how glottalized stops are produced, it is helpful to understand how the so-called glottal stop itself is produced. The glottal stop is the sound written '/' in the established Navajo writing system. Recall that the vocal bands in the larynx are capable of being tightly shut so that no breath may pass upward through the larynx. One holds one's breath by closing the vocal bands. This is precisely what is done when a glottal stop is produced. In fact, when a person is holding his breath, he is producing a prolonged glottal stop. The term glottal stop derives from the term glottis, which refers to the space between the vocal bands.

The stop consonants we have been studying up to now should properly be called oral stops, since they are produced by creating an obstruction in the mouth (or oral cavity) by means of the tongue or lips. Now, it is obviously possible to produce an oral stop and a glottal stop at the same time -- i.e., it is perfectly possible to put the lips or tongue into some stop position and, at the same time, to have the vocal bands tightly shut. And, in fact, this is what happens when a glottalized stop is produced. A glottalized stop is an oral stop and a glottal stop produced simultaneously. The acoustic effect which
we have referred to as a "snap" or "pop" is achieved in the following way. An oral stop is produced, and at the same time, the vocal bands are tightly closed. This traps a certain amount of air in the mouth and throat between the oral stoppage and the larynx. The closed larynx is raised slightly, creating pressure in the mouth and throat. When the oral stoppage is opened, the pressure is suddenly released -- and it is this sudden release of pressure which one perceives as a "snap" or "pop". Immediately after the pressure is released, the glottal closure is also released. All of this happens very fast in normal speech, but it is quite possible to slow the sequence of events down so that it can be perceived step by step. In particular, it is possible to lengthen the time between the release of the oral closure and the release of the glottal closure: t...'. This makes it rather easy to see what a glottalized stop is composed of. The following series of x-ray profiles is offered in an attempt to illustrate the events which take place in the production of the apico-alveolar glottalized stop /t'/ in a syllable such as /t'a/:
1. Simultaneous apico-alveolar stop articulation and glottal stop.

2. The larynx slightly raised, creating pressure in the mouth and throat.
3. Apico-alveolar stoppage is opened, releasing the pressure pent up in the mouth and throat.

4. Vocal bands are parted so that breath from the lungs may resume its outward flow - at this point, the vowel of the syllable is begun.
The glottalized stops can be incorporated into the phonetic chart as follows:

<table>
<thead>
<tr>
<th></th>
<th>bilabial</th>
<th>apico-alveolar</th>
<th>lamino-alveolar</th>
<th>dorso-velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>stops</td>
<td>unaspirated</td>
<td>b</td>
<td>d</td>
<td>j</td>
</tr>
<tr>
<td></td>
<td>aspirated</td>
<td>-</td>
<td>t</td>
<td>ch</td>
</tr>
<tr>
<td></td>
<td>glottalized</td>
<td>-</td>
<td>t'</td>
<td>ch'</td>
</tr>
<tr>
<td>fricatives</td>
<td>voiceless</td>
<td>-</td>
<td>s</td>
<td>sh</td>
</tr>
<tr>
<td></td>
<td>voiced</td>
<td>-</td>
<td>z</td>
<td>zh</td>
</tr>
<tr>
<td>nasals</td>
<td></td>
<td>m</td>
<td>n</td>
<td>-</td>
</tr>
</tbody>
</table>

As we pointed out before, whenever a phonetic chart is filled out for any language, we notice that there are certain points in the chart which are empty. In the above chart, for example, the intersection of the nasal row and the dorso-velar column is empty -- that is to say, there is no dorso-velar nasal in Navajo. We have also seen that languages differ in what sounds they have. Thus, English has a dorso-velar nasal, but it lacks the glottalized consonants altogether. And if we had a phonetic chart for Hopi, we would see that it has only one series of stop consonants, while Navajo has three series.

One of the interesting facts about Navajo is that it has relatively few labial sounds. It has an unaspirated bilabial stop /b/ and a bilabial nasal /m/, but it does not have the following
theoretically possible bilabials:

- aspirated bilabial stop
- glottalized bilabial stop
- voiceless bilabial fricative
- voiced bilabial fricative

These sounds are, however, found in some languages of the world. The aspirated bilabial stop is common in Taos and some dialects of Tewa -- the phonetic symbol normally used for it is [pʰ]. A glottalized bilabial stop -- represented [p'] -- is found in all the Tanoan languages (Taos, Tewa, and Jemez). A voiceless bilabial fricative -- commonly represented by the Greek letter [φ] -- is found in Jemez. And a voiced bilabial fricative -- represented in phonetic notation by the Greek letter [β] -- is found in Spanish, i.e., the b and v of lobo and uva (see III above).

4. Exercises.

(1) English /f/, as in fine, and /v/, as in vine, are labio-dental fricatives. What is the difference between them?

(2) The English sound written th in words like thick, thing, etc. is a lamino-dental fricative -- it is
represented by the Greek letter \( \theta \) in phonetic transcription. English has another lamino-dental sound, also written \( \text{th} \), which appears in words like this, the, there, that -- this sound is represented by the Greek letter \( \delta \) in phonetic transcription. The sounds \( \theta \) and \( \delta \) are both lamino-dental fricatives. What is the difference between them?

(3) In Navajo, the feature voice is used to distinguish /z/ from /s/, /zh/ from /sh/, and /gh/ from /x, h/. But other Navajo consonants can also be classified as voiced or voiceless. Which of the following classes of sounds are voiced in Navajo?

- aspirated stops
- glottalized stops
- unaspirated stops
- nasals

One way to test for voicing is to put a sound between two vowels -- e.g., /ada/, /ana/, and so on -- and pronounce the sequence to determine whether the voicing cuts off when you reach the sound you are testing. Vowels are voiced, so if
you want to test whether or not /t/ is voiced or voiceless, put it in the sequence /ata/, pronounce the sequence while holding your hands over your ears, if the voicing (or buzzing sound) cuts off momentarily when you reach the /t/, then /t/ is voiceless; but if the voicing does not cut off, then /t/ is voiced.

(4) Some of the sounds of Navajo were not discussed in this section, although they can be classified with respect to the features of voice, aspiration and glottalization. Classify the following sounds according to these manners of articulation:

/dz/ as in dzééh.
/ts/ as in tsín.
/ts'/ as in ts'ín.
/dl/ as in dloó'.
/tl/ as in tláh.
/tl'/ as in tl'éé'.
/l/ as in lájish.
/l/ as in lóó'.

(5) We are accustomed to representing sounds "alphabetically", i.e., with "letters" like b, a, or combina-
tions of letters, like ch, sh, and so on. What we are beginning to learn here is that a sound can also be represented as "a list of things that are true of it". For example, Navajo /t/ can be represented (in part, at least) by the following list.

stop
apico-alveolar
aspirated

This way of representing sounds is sometimes referred to as a feature representation, because each of the things which is true of a sound is one of its "features". Thus, we can define a sound in any language as a particular "bundle of features" or, more precisely, as a "bundle of phonological features". When sounds are represented this way, the features are often enclosed in square brackets.

Identify the Navajo sounds which correspond to the following feature representations:

(i) [stop
  lamino-alveolar
  glottalized]
(ii) fricative
    dorso-velar
    voiced

(iii) nasal
    bilabial

(iv) stop
    dorso-velar
    aspirated

(6) Describe what happens during the production of the nasals in the following words:

/yii'mas/ 'we are rolling along'
/dii'ní/ 'we say'

What kind of sound are these?
5. Answers.

(1) /f/ is voiceless; /v/ is voiced.

(2) /θ/ is voiceless; /ð/ is voiced.

(3) aspirated, glottalized and unaspirated stops are all voiceless; nasals are voiced.

(4) /dz, dl/ unaspirated
/ts, tl/ aspirated
/ts', tl'/ glottalized
/l/ voiced
/l'/ voiceless

(5) (i) /ch'/
(ii) /gh/
(iii) /m/
(iv) /k/

(6) These sounds are ordinary bilabial and apico-alveolar nasals interrupted by a glottal stop. They can be referred to as glottalized nasals.
V. The Manners of Articulation:

*Laterality; Release Features; Rounding.*

1. In the last section, it was pointed out that the concept "manner of articulation" has to do with what happens to the breath during the production of speech sounds -- the breath may be interrupted (as it is when a stop consonant is produced), it may be forced through a restricted passage in the oral cavity (as for fricatives); routed along a particular path (e.g., through the nasal passage); or it may be set into vibration (as in producing voiced sounds).

Notice that we have included among the manners of articulation the route along which the breath travels in its outward movement. A principal "routing distinction" which functions in many languages is that which opposes *nasal* and *oral* (i.e., routing the breath through the nose as opposed to routing it through the mouth). It happens that within the oral route, there is an additional routing distinction which functions to differentiate sounds in many languages -- it is especially functional in Navajo. Consider, for example, the difference between /s/ and /t/, as in the pair

/sid/ 'scar'
/til/ 'smoke'

The difference between these sounds depends precisely on the route
along which the outgoing breath travels when the sounds are produced. In the case of /s/, the breath passes straight out over the tip of the tongue, while is the case of /ʔ/, the breath passes around the sides of the tongue (the tip itself makes contact at apico-alveolar position). Both sounds are fricatives, since for both, the breath is set into local turbulence as it moves through the restricted passage created by the tongue. And both sounds are apico-alveolar, since the tip of the tongue is either close to (in the case of /s/) or against (in the case of /ʔ/) the alveolar ridge. They differ only with respect to the route by which the breath exits.

It is customary and appropriate to refer to sounds like /ʔ/ as laterals (based on Latin latus, lateris "side"), since in their production the breath passes around the sides of the tongue. We may contrast this term with median (based on Latin medius "middle") which might be used in referring to sounds like /s/ produced with a breath flow moving along the median line (i.e., without sideward deviation). Thus, in the apico-alveolar position of articulation, Navajo distinguishes median and lateral voiceless fricatives: /s/ as opposed to /ʔ/. But this is not all. Navajo is extremely rich in laterals. Just as the voiceless fricative /s/ has a voiced counterpart /z/, so /ʔ/ has a voiced counterpart /l/. (Although /l/ is not technically a fricative, since it is not produced with the "friction" characteristic of /s/ and /ʔ/, it is nonetheless...
quite clearly the voiced counterpart of /±/ and, therefore, will be classed with it among the fricatives.) And also, in the stop series, the median/lateral distinction is functional. The stops /d, t, t'/ each have a counterpart which is characterized by lateral release: /dl, tl, tl'/. The distinction between these two sets of stops consists in the routing of the outflowing breath upon their release -- when the median stops /d, t, t'/ are released, the breath flows outward along the median line (i.e., straight out); but when the lateral stops are released, the breath exits around the sides of the tongue.

The median/lateral distinction might be incorporated into the phonetic chart as follows:

<table>
<thead>
<tr>
<th></th>
<th>apico-alveolar</th>
<th>bilabial</th>
<th>median</th>
<th>lateral</th>
<th>lamino-alveolar</th>
<th>dorso-velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>stops</td>
<td>unaspirated</td>
<td>b</td>
<td>d</td>
<td>dl</td>
<td>j</td>
<td>g</td>
</tr>
<tr>
<td></td>
<td>aspirated</td>
<td>-</td>
<td>t</td>
<td>tl</td>
<td>ch</td>
<td>k</td>
</tr>
<tr>
<td></td>
<td>glottalized</td>
<td>-</td>
<td>t'</td>
<td>tl'</td>
<td>ch'</td>
<td>k'</td>
</tr>
<tr>
<td>fricatives</td>
<td>voiceless</td>
<td>-</td>
<td>s</td>
<td>l</td>
<td>sh</td>
<td>x, h</td>
</tr>
<tr>
<td></td>
<td>voiced</td>
<td>-</td>
<td>z</td>
<td>l</td>
<td>zh</td>
<td>gh</td>
</tr>
<tr>
<td>nasals</td>
<td></td>
<td>m</td>
<td>n</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Notice that in this chart, the median/lateral opposition exists only in the apico-alveolar position of articulation. However, it is theoretically possible to make this distinction in any of the positions except bilabial -- this is so because it is always possible to manipulate the tongue in such a way as to allow the breath to
to pass out around the sides of it. Dorso-velar laterals are extremely rare among languages of the world, but they are found in some of the languages of New Guinea. However, lamino-alveolar laterals are not so uncommon. Some speakers of English use a lamino-alveolar lateral in the word million; and in Castilian Spanish (in Spain), the sound written ll is a lamino-alveolar lateral (though it is pronounced [y] in the Spanish of Latin America) -- this sound may be represented [ɾ] or [l̃] in phonetic transcription.

One might also ask whether or not a lateral nasal could exist. Such a sound would be produced by allowing the breath to flow out through the nasal cavity and simultaneously around the sides of the tongue and out the mouth. This is certainly possible, and is, in fact, recorded for some languages of South America -- lateral nasals might be represented [ɾ] or [l̃] in phonetic transcription.

2. As we have just seen, Navajo makes a distinction among its apico-alveolar stops according to whether they have a median release or a lateral release. This is not the only distinction which depends upon the way in which a stop is released. Let us examine now the difference between /d/ and /dz/, as in the pair of words

/di:/ 'blood'
/dzi:/ 'mountain'
We know that /d/ is an apico-alveolar median stop. But what sort of sound is /dz/? If we study it closely, we see that it shares a great deal with /d/. It is apico-alveolar, clearly. And since it is not produced with a lateral release, it is median, like /d/. If we pronounce /dz/ very slowly, we notice also that there is a period of time at the very beginning of its production when the outward flow of breath is interrupted — it is therefore a stop. So both /d/ and /dz/ can be classified as apico-alveolar median stops. The essential difference between the two is the way in which they are released: /d/ has what we might call a "simple" release, while /dz/ has a "fricative" release. When /d/ is released, the tip of the tongue is suddenly and completely withdrawn from the apico-alveolar position — one might say that it is released in a single step. But when /dz/ is released, two steps are involved: first, the tip of the tongue is lowered only slightly, creating a restricted passage through which the breath can escape (this accounts for the z-like sound which is characteristic of the release of /dz/); second, the tip of the tongue is completely withdrawn from the apico-alveolar position. One way to characterize /dz/ is to say that it begins as a stop sound and ends as a fricative — and this is certainly what is reflected in the way it is written: /d + z/. Sounds of this type — i.e., which begin as stops and end as fricatives are sometimes called affricates (based on the Latin verb *affricare* "to rub against"). Another way to think of
the distinction between /d/ and /dz/ is in terms of the relative speed with which their releases are achieved: the release of /d/ is quick or abrupt, since it involves only one step, while the release of /dz/ is slow or delayed, since it involves two steps (i.e., release of the stop part and then release of the fricative part). This way of looking at the distinction has given rise to the terms abrupt release and delayed release now used by some linguists in reference to the distinction between simple and affricated stops. The distinction between abrupt and delayed release is not limited to the unaspirated pair /d, dz/; it also distinguishes /t/ from /ts/, and /t'/ from /ts'/:

<table>
<thead>
<tr>
<th>stops</th>
<th>unaspirated</th>
<th>aspirated</th>
<th>glottalized</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b</td>
<td>t</td>
<td>t'</td>
</tr>
<tr>
<td></td>
<td>d</td>
<td>ts</td>
<td>ts'</td>
</tr>
<tr>
<td></td>
<td>dz</td>
<td>tl</td>
<td>tl'</td>
</tr>
<tr>
<td></td>
<td>dl</td>
<td>ch</td>
<td>ch'</td>
</tr>
<tr>
<td></td>
<td>j</td>
<td>k</td>
<td>k'</td>
</tr>
<tr>
<td>fricatives</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>voiceless</td>
<td>s</td>
<td></td>
<td>l</td>
</tr>
<tr>
<td>voiced</td>
<td>z</td>
<td></td>
<td>zh</td>
</tr>
<tr>
<td></td>
<td>ɻ</td>
<td></td>
<td>gh</td>
</tr>
<tr>
<td>nasals</td>
<td>m</td>
<td>n</td>
<td></td>
</tr>
</tbody>
</table>

According to this chart, the only delayed release stops are those found in apico-alveolar position. However, if one studies the lamino-alveolar stops carefully, one must conclude that they are also delayed release stops, since under "microscopic" examination they prove to be composed of a stop component and a fricative component. Thus, just as /dz/ can be said to begin as a stop /d/ and end as a fricative /z/, so the lamino-alveolar /j/ could be said to begin as the stop /d/ and end as the fricative /zh/. However, in Navajo, there is no distinction between abrupt and delayed release among the lamino-alveolars. It is phonetically true of them that they have a delayed release, but we do not mention this in the chart because there is no opposing set of lamino-alveolars with abrupt release. In other words, delayed release is a redundant feature in association with lamino-alveolars. But in association with the apico-alveolars, it is a distinctive feature, since it serves to distinguish different sounds.

3. It has been pointed out that Navajo has relatively few labial sounds. In fact, we have had very little reason to mention the lips since we discussed the bilabial position of articulation. However, there is an additional manner of articulation which involves the lips crucially. Consider the distinction between /k/ and /kw/, as in the pair of words:
/kii/ 'Kee'  
/kwii/ 'here'

Both /k/ and /kw/ are aspirated dorso-velar stops, but the first is produced with the lips in a rather neutral position, while the second is produced with rounded lips. It is customary to refer to /kw/ as a rounded dorso-velar stop; its counterpart /k/ is unrounded. Most of the dorso-velar consonants of Navajo are unrounded -- there are rounded counterparts only for the aspirated stop and for the voiceless fricative:

<table>
<thead>
<tr>
<th></th>
<th>unrounded</th>
<th>rounded</th>
</tr>
</thead>
<tbody>
<tr>
<td>stops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>unaspirated</td>
<td>g</td>
<td>-</td>
</tr>
<tr>
<td>aspirated</td>
<td>k</td>
<td>kw</td>
</tr>
<tr>
<td>glottalized</td>
<td>k'</td>
<td>-</td>
</tr>
<tr>
<td>fricatives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>voiceless</td>
<td>x, h</td>
<td>hw</td>
</tr>
<tr>
<td>voiced</td>
<td>gh</td>
<td>-</td>
</tr>
</tbody>
</table>

In Navajo, the feature of rounding combines with consonants at dorso-velar position only. And this is the commonest thing in languages of the world -- if a language has rounded consonants, they

---

3. It may turn out that Navajo also has a rounded voiced dorso-velar fricative, in addition to the rounded voiced dorso-velar fricative which is a variant of /gh/ before rounded vowels, as in /yilghoɁ/ [yilwoɁ]. The /w/ of the word /waa'/ 'beeweed' may be a rounded dorso-velar fricative. Paul Platero informs me that it would probably become a rounded unaspirated velar stop under the "d-effect" in a hypothetical verb form like

/na-ɨiɁ-waɁ/  
'we are beeweeding around'

He suggests that this form, if it existed, would be [neiɁwaa']. If so, then this /w/ must be a rounded dorso-velar fricative.
are normally dorso-velars. Thus, for example, Hopi has a rounded dorso-velar stop and a rounded dorso-velar nasal -- these are commonly written \([k^w]\) and \([\eta^w]\) in phonetic notation. But it is also possible to combine rounding with consonants in other positions of articulation -- e.g., \([t^w]\), \([p^w]\), etc. -- and such sounds are recorded for some languages. Yaqui, for example, has a voiced rounded bilabial stop \([b^w]\).

4. Exercises.

(1) For each of the following feature representations, identify the corresponding Navajo consonant:

(1) \[
\begin{array}{l}
\text{stop} \\
\text{apico-alveolar} \\
\text{median} \\
\text{abrupt release} \\
\text{glottalized} \\
\end{array}
\]

(ii) \[
\begin{array}{l}
\text{fricative} \\
\text{apico-alveolar} \\
\text{lateral} \\
\text{voiceless} \\
\end{array}
\]
(iii) fricative
   apico-alveolar
   median
   voiced

(iv) stop
   dorso-velar
   rounded
   aspirated

(v) stop
   bilabial
   unaspirated

(2) Give the feature representations corresponding to the following Navajo consonants:

(i) /zh/
(ii) /k'/
(iii) /dl/
(iv) /t/
(v) /n/.

(3) Suggest appropriate feature representations for the English consonants which are underlined in the
following words:

(i) thick
(ii) fine
(iii) quiet
(iv) chicken
(v) song
(vi) pleasure

(4) In Navajo, we have classified /l/ as a fricative, because it is the voiced counterpart of /ʎ/. However, from a strictly phonetic point of view, Navajo /l/ is not a fricative, because it is not produced with "friction" the way /ʎ/ is. Technically, Navajo /l/ is a liquid. A liquid, like a fricative, is produced by adjusting the tongue so that the breath can exit through a narrow passage -- however, in the case of a liquid, the passage is not as narrow as that for a fricative and, consequently, when the breath passes through, it is not set into turbulence. Navajo /l/ is produced with a lateral passage -- it is, therefore, a lateral liquid. It is also possible to produce a median liquid, although none exists in Navajo.

In light of this discussion, attempt to classify the following English sounds:
/l/ as in lake.
/r/ as in rake.

(5) Describe the lateral consonant in the word /wóˈālliwo/ 'it is overflowing'.

(6) The card game for consonant features. (In one version of the game, let redundant features count one-half value only.)
5. Answers

(1) (i) \(/t'/, (ii) \(/\), (iii) \(/z/, (iv) \(/kw/, (v) \(/b/.

(2) (1) fricative
lamino-alveolar
voiced

(ii) stop
dorso-velar
unrounded
glottalized

(iii) stop
apico-alveolar
lateral
unaspirated

(iv) stop
apico-alveolar
median
aspirated

(v) nasal
apico-alveolar
median
(3) (1) fricative
lamino-dental
voiceless

(ii) fricative
labio-dental
voiceless

(iii) stop
dorso-velar
rounded
aspirated

(iv) stop
lamino-alveolar
aspirated

(v) nasal
dorso-velar

(vi) fricative
lamino-alveolar
voiced
(4) English /l/: lateral liquid.
    English /r/: median liquid.

(5) The lateral here is nasalized due to the nasality of the surrounding vowels.

(6) Card game.
VI. Vowels.

1. We turn now to a fundamental phonological opposition which serves to partition the sounds of a language into two major classes. This is the opposition between consonants and vowels. The sounds discussed in the foregoing sections are all consonants.

The basic vowel-types in Navajo are four in number: /a,e,i,o/. They are exemplified in the following words:

/gah/  'rabbit'
/abe'/  'milk'
/tin/   'ice'
/dloh/  'laughter'

The principle which distinguishes vowels from consonants can be described in terms of what happens in the oral passage during their production. When a vowel is produced, there is no obstruction whatsoever in the oral passage -- the breath is allowed to exit through the mouth with complete freedom. The function of the oral cavity in the pronunciation of vowels is to modify in various ways the freely flowing column of air (i.e., breath), set into vibration by the action of the vocal bands, and thereby to produce the acoustic effects which distinguish one vowel from another -- it therefore functions much as does the body of a stringed instrument; just
as distinct stringed instruments sound different because of differences in the shapes and sizes of their bodies, so distinct vowels sound different because of differences in the shape and relative size of the oral cavity during their production. The modifications in the oral passage are accomplished in part by adjusting its size, by adjusting the overall position of the tongue, and by adjusting the attitude (e.g., the relative degree of rounding) of the lips. But for any vowel, the breath is allowed to pass through the oral cavity without hindrance. This is the principal distinction between vowels and consonants -- vowels are produced with no oral obstruction, while consonants are produced by creating an obstruction of some sort in the oral cavity. The obstructions associated with the production of consonants vary in degree and kind: in the case of stops, the obstruction is maximum in that it momentarily interrupts the breath-flow completely; in the case of nasals, the oral cavity is again completely obstructed, but the breath is allowed to escape through the nasal passage; and in the case of fricatives, the breath is forced to flow through a constricted passage. Liquids (e.g., the Navajo voiced lateral /l/, and English /l,r/) exhibit a relatively lesser degree of oral obstruction, since the breath is allowed to exit with considerably less hindrance than is the case for fricatives; nonetheless, liquids involve some degree of obstruction, unlike vowels which involve none whatsoever.

In short, vowels are characterized by an unobstructed oral
passage, while consonants are characterized by an obstructed oral passage. This classification of linguistic sounds is fundamental, and it is probably universal for all human language. However, there are other sounds which exist but which do not fit in any obvious way into either the consonant class or the vowel class, at least as these classes are defined above. For example, the glides /w/ and /y/ have much in common with vowels from an articulatory point of view, since they are pronounced with an unobstructed oral passage; on the other hand, they pattern like consonants in terms of their distribution within words -- like consonants, they can appear word-initially, as in /waa'/ 'beeweed', and /yoo'/ 'beads, necklace'. The glide /w/ is produced with rounded lips and with the back of the tongue relatively raised, like the vowel /o/; and the glide /y/ is produced with the body of the tongue relatively advanced and raised, which as will be seen presently, is the principle articulatory characteristic of the vowel /i/. The major difference between the glides /w,y/ and their vowel counterparts /o,i/ is the fact that the vowels are syllabic, while the glides are not. It is not a particularly simple matter to define the notion 'syllabic', but for Navajo, it is sufficient to say that the syllabic segments are those which are capable of carrying tone -- that is to say, they appear either with low tone (as /i/ in the word /ni/'you') or with high tone (as /i/ in the word /ni/'he said'). According to this definition

---

4. See footnote 3 in which it is suggested that /w/ is really a voiced rounded dorso-velar fricative.
the syllabic segments are the vowels; the glides are, correctly, not syllabic under this definition. The non-syllabic nature of glides can be illustrated in another way. The structure of Navajo syllables is such that the first segment in a syllable is always non-syllabic (a consonant or a glide), and the second is always syllabic (in fact, it is always a vowel); a syllable may end in a vowel or in one of a restricted set of non-syllabics. These patterns are typically represented by the formulae CV and CVC (where C stands for consonant, V for vowel) -- the pattern CV is exemplified by such words as /tó/ 'water', /ké/ 'shoe', /ni/ 'you', and the pattern CVC is exemplified by such words as /iid/ 'smoke', /kin/ 'house', /k'ish/'áldér'. The glides /w/ and /y/ appear in the initial C-position, never in the V-position, in Navajo syllables. For this reason, it is customary to include the glides in the same chart with consonants -- in a bottom row labelled glide, with /w/ in either the bilabial column or the dorso-velar column, and /y/ in the lamino-alveolar column (although, phonetically, it is in centro-domal position).

Another class of sounds not obviously included among vowels or consonants are the laryngeals (or glottals) -- i.e., those sounds whose defining properties have to do solely with the action of the larynx. One of these is the glottal stop /ʔ/ (written [ʔ] in phonetic notation) produced by bringing the vocal bands tightly together, thereby stopping the breath flow at the larynx. The glottal stop is not a consonant under the definition given above,
nor is it a vowel -- the defining characteristics of vowels and consonants involve the oral cavity in an essential way, while for the glottal stop, the events taking place in the oral cavity are irrelevant. Nonetheless, the glottal stop patterns like a consonant in the syllable structure of Navajo -- i.e., it occurs in the C-positions. Another laryngeal which occurs in Navajo is the glottal spirant (or glottal fricative) written /h/ in the usual orthography -- it is not to be confused with the dorso-velar fricative, also written /h/ (but also, and from a phonetic point of view, more appropriately /x/). The glottal spirant is produced by parting the vocal bands in such a way as to allow the breath to pass through the glottis without setting the vocal bands into vibration; instead, the breath is set into slight turbulence as it passes through the glottis. The Navajo glottal spirant is heard finally in such words as /'e'e'aah/ 'west', /dineéh/ 'young man', /diniih/ 'pain, ache'. It is also heard in other positions in the word, often as a variant pronunciation of the voiceless dorso-velar continuant -- there has, in fact, been some debate among students of Navajo as to whether the glottal spirant and the voiceless dorso-velar spirant are phonologically distinct in the language. Since the laryngeals pattern like consonants in Navajo syllable structure, it is customary to include them in the consonant chart -- in a column at the extreme right labelled laryngeal, with /'/ in the same row as the glottalized stops and with /h/ in the same row as the voiceless fricatives.
2. The usual way to classify vowels is to make reference to the overall position which the tongue assumes when a vowel is being produced; however, since the positioning of the tongue is in part dependent on the action of the lower jaw, it is relevant also to make reference to the relative degree of mouth opening. Consider first the difference between the vowel /a/ and the vowel /i/. Start by pronouncing /i/ in isolation, then follow it immediately by the vowel /a/ -- what one notices is that the lower jaw drops very perceptibly as one changes from /i/ to /a/. Conversely, if one starts by pronouncing /a/ and follows this with /i/, the jaw rises. The effect of this is to vary the degree of mouth opening -- the mouth is open widest during /a/, and the opening is narrowest during /i/. In addition, the overall vertical positioning of the tongue is effected -- when the jaw is raised, the tongue is also raised, or, to put it another way, the tongue is relatively high in the mouth; and when the jaw is lowered, the tongue is relatively low in the mouth. These observations give rise to one of the dimensions which is fundamental to the classification of vowels from the articulatory point of view -- namely, the dimension of tongue height. Within this dimension, /i/ is classified as a high vowel, /a/ as a low vowel.

Now compare the vowel /e/ with the two just described -- in proceeding from /i/ to /e/ and then to /a/, one observes that the position of the jaw during /e/ is roughly midway between the high
position which characterizes /i/ and the low position which characterizes /a/; /e/ is therefore a mid vowel.

Now consider /o/ -- again, in proceeding from /i/ to /o/ and then to /a/, one observes that the jaw is in roughly the mid position relative to the high position of /i/ and the low position of /a/; and this observation is further confirmed by the fact that when one compares /o/ and /e/, by pronouncing one after the other, there is no change in the relative position of the jaw along the dimension of height. That is to say, /e/ and /o/ are both mid vowels. But there is a difference between them, in fact, there are two differences. Notice for one thing that when /o/ is pronounced the lips are rounded, but when /e/ is pronounced, they are unrounded. The other difference has to do with the relative position of the tongue along the horizontal, or front-back, dimension -- when /e/ is pronounced, the tongue is relatively advanced, or front, within the mouth; but when /o/ is pronounced, the tongue is relatively retracted, or back. This relative positioning of the tongue can be observed by touching the tip of the tongue with a small stick while pronouncing /e/ and /o/ in succession; as one proceeds from /e/ to /o/, the tip of the tongue can be felt to retreat slightly into the mouth.

The horizontal dimension is the second principal one used in the classification of vowels -- among the Navajo vowels, /e/ is a front vowel, and /o/ is a back vowel. The vowels /i/ and /a/
participate in this dimension as well. A comparison of /e/ and /i/ reveals that the horizontal position of the tongue is the same for both -- i.e., both are front vowels. Similarly a comparison of /o/ and /a/ reveals the same general horizontal positioning of the tongue -- both are back vowels.

It is possible at this point to present the basic vowel types of Navajo in the form of a chart which incorporates the major articulatory dimensions, together with the feature of lip rounding:

```
  front       back
    \       /  \
  \  |   /    \
  high  i  \  |   /    \
    \  |   /    \
  mid  e       o
    \  |   /    \
  low          a
```

Notice that we have failed to indicate whether the front vowels are rounded or unrounded -- they are in fact unrounded; we have left this notation out of the chart because of the fact that there is no distinction between rounded and unrounded among front vowels of Navajo, only the back vowels participate in this opposition.

There are a number of theoretically possible vowels which are not included in the chart. The most important gap is that which appears in the high back rounded position in the chart. It is a
fact of the Navajo sound system that there is no high back
rounded vowel -- this missing vowel is /u/ (i.e., very roughly
the sound represented by oo in the English words boot, shoot,
too). If Navajo had this vowel as a distinctive phonological
segment, then the Navajo vowel system would be of the five-vowel
type

\[
\begin{array}{ccc}
  & u & \\
  i & e & o \\
  a
\end{array}
\]

so common among the languages of the world -- e.g., the vowel
systems of Spanish, Tewa, Yaqui, Hawaiian, and many other languages
are of this five-vowel type. But Navajo has a four-vowel system,
which is also common among the languages of the world. What this
suggests, in relation to the present discussion, is that it is
a mistake to chart the Navajo vowels in this roughly triangular
fashion, as if they belonged to a five vowel system. It seems
more appropriate to represent the system in the form of a
rectangular chart which reflects the relative, rather than the
absolute tongue height among the front and back vowels:

\[
\begin{array}{ccc}
  \text{front} & \text{back} \\
  \text{high} & i & o \\
  \text{low} & e & a
\end{array}
\]

Although it is incorrect, from a strictly phonetic point of view,
to say that /e/ is low and /o/ is high, it is in fact correct to classify these vowels as low and high from the relative point of view -- /e/ is low relative to its fellow front vowel /i/, and /o/ is high relative to its fellow back vowel /a/. And in the case of /o/, there is even some phonetic justification for classifying it as high -- it ranges to high, i.e., phonetic [u], when followed by /i/, as in forms like /deesdoi/ (pronounced [deesdui]) 'it is hot'.

The feature [rounded] is distributed among the vowels in the following manner: /o/ is [rounded], while all the others are [unrounded]. The feature compositions of the basic Navajo vowel types, in accordance with the revised (or rectangular) classification, are as follows:

\[
\begin{array}{cccc}
/i/ & /e/ & /o/ & /a/ \\
\text{vowel} & \text{vowel} & \text{vowel} & \text{vowel} \\
\text{high} & \text{low} & \text{high} & \text{low} \\
\text{front} & \text{front} & \text{back} & \text{back} \\
\text{unrounded} & \text{unrounded} & \text{rounded} & \text{unrounded} \\
\end{array}
\]

3. The four-vowel system provides the basic foundation of the vowel distinctions in Navajo. However, it is not the case that Navajo has only four vowels. Each of the basic vowel types